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Five-Year Results of a Ponderosa Pine Provenance Study in the Black Hills

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Survival and height growth data were collected after five field growing seasons from ponderosa pine progeny representing 75 provenances of natural stands in the Great Plains and Northern Rockies. Results showed that trees from no other provenance survived significantly better or grew significantly taller than trees from the Black Hills. Trees from southern Colorado, New Mexico, and western Montana showed significantly poorer survival and height growth.

High mortality evidently resulted from a combination of intense grass competition and root rot.

Keywords: Provenance study, *Pinus ponderosa*.

Ponderosa pine (*Pinus ponderosa*) is so adaptable that it is the most widely distributed pine in North America. The Rocky Mountain, or interior form, *scopulorum*, occupies an extensive range east of the Continental Divide from Montana and North Dakota south into New Mexico.

In the Black Hills of South Dakota and Wyoming, more than 95 percent of the growing stock is ponderosa pine. Reproduction is usually abundant, even without management to encourage it. With thinning to stimulate growth, gross wood production is highly satisfactory. There is a possibility, however, that the evident genetic diversity of the species might endow trees from some other provenances with an inherent potential for more rapid, high quality growth than that of the local stock.

This Note reports early results of the Black Hills phase of a large racial variation study which is intended to identify provenances of ponderosa pine best suited for Plains forestry. The natural forest environment of the Black Hills provides an excellent opportunity to compare the performance of trees representing a large number of nonlocal sources with performance of Black Hills trees.

Methods

Seeds and Seedlings

Seeds were collected from the eastern range of ponderosa pine under the direction of David H. Dawson and Ralph A. Read.[2] Locations of the 75 provenances providing seedlings for the Black Hills trial are shown in figure 1.

Stock for the Black Hills Experimental Forest plantation was grown at the Forest Service's Bessey Nursery, Halsey, Nebraska. Seedlings were outplanted as 2-1 stock in spring 1968; first-year failures were replaced the next spring with 2-1-1 stock of the same source.

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[2]*Present assignment for Dawson is the Institute of Forest Genetics, USDA Forest Service, Rhinelander, Wisconsin; for Read, Rocky Mountain Forest and Range Experiment Station, Lincoln, Nebraska.*

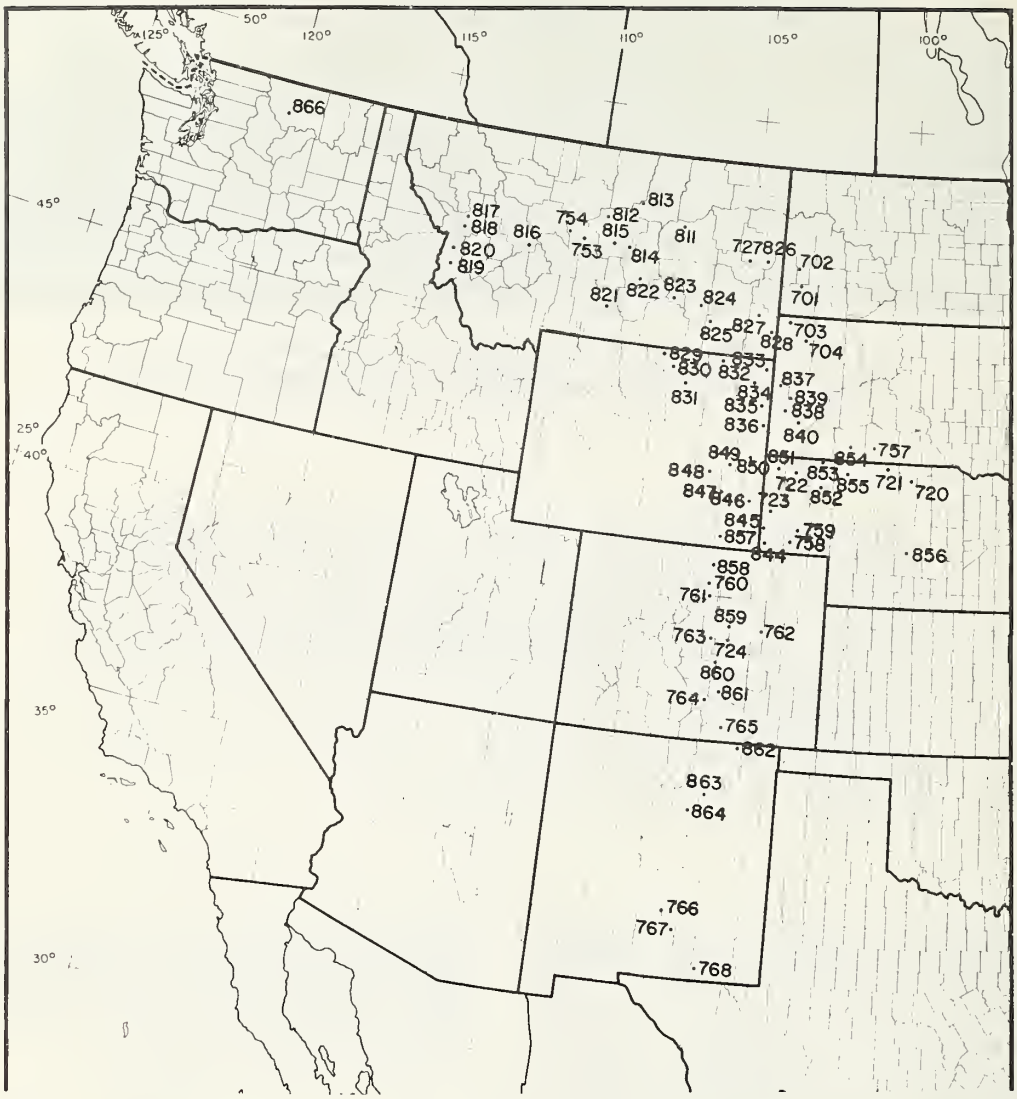

Figure 1.—Location of seed sources for 75 provenances of ponderosa pine being tested on the Black Hills Experimental Forest.

Planting Site

Site index of the relatively level planting area is about 60 (base age 100)—slightly better than average for the central Hills. The site had formerly been occupied by a two-storied stand of ponderosa pine—saplings under sawtimber. A few small patches of aspen (*Populus tremuloides*) were cut from the understory. All trees were cut from the test site during the winter of 1967-68. Pines exceeding minimum merchantable requirements (6.0 inches d.b.h., outside bark) were harvested commercially as roundwood, even though some stems were sawtimber size. Slash and most small stems were chipped and scattered as much as practicable. Material not chipped was piled in windrows between planting rows.

Design and Installation

The 3,000 seedlings in the plantation were hand planted at 8-ft-square spacings in randomized blocks. Each source is represented once in each of 10 blocks (replications) by a 4-tree linear plot. A single row of seedlings from a local source, planted at an 8-ft-spacing, surrounds the plantation as a buffer strip. Approximately 25 ft separates the buffer seedlings from the adjacent natural stand.

Circles about 2 ft in diameter were scalped around each planting spot to reduce vegetative competition. Two more scalping treatments at yearly intervals maintained a nearly competition-free growing condition for each tree during its first 3 years in the field. Repeated scalping is more cultivation than is normally provided, but some site preparation is needed in all Black Hills plantations to keep encroaching vegetation from choking out the trees.

Inspections and Measurements

Survival was determined yearly; heights of all seedlings were measured after 3 and 5 years in the field. Total seedling height and current annual leader growth were measured. During each of the yearly inspections, any damage to seedlings was noted, and cause for mortality was determined whenever possible.

Results and Discussion

After 5 years in the plantation, survival and growth of trees from each provenance were compared with those for provenance SD 839, which originated nearest the Black Hills Experimental Forest. Trees from no other provenance survived significantly better or grew significantly taller on the average than SD 839, while average survival was significantly less for 21 provenances and average heights were significantly shorter for 15 provenances (table 1). Most of the poorer survival and growth came from trees of provenances farthest from the Black Hills. Trees from southern Colorado, New Mexico, and western Montana were the poorest performers. The poor survival and growth of trees from the Bitterroot Valley of western Montana are in contrast to the generally favorable performance achieved in North Dakota reported by Conley, Dawson, and Hill.[3]

Washington provenance 866 is one of the most distant from the Black Hills. Unlike trees from provenances far to the South, those of number 866 survived as well as comparison source 839. Height growth was not as good, however. Height growth, unlike survival, can be improved over time, especially if growth in the early years is affected only by some physical damaging agent.

Survival during the first 3 years in the field was exceptionally good, averaging 86.7 percent:

(Year)	Survival (Number)	(Percent)
1969	2795	93.2
1970	2601	86.7
1971	1820	60.7
1972	1146	38.2

[3]*Conley, William T., David H. Dawson, and Robert B. Hill. 1965. The performance of eight seed sources of ponderosa pine in the Denbigh Experimental Forest, North Dakota. U.S. For. Serv. Research Note LS-71, 4 p. Lake States For. Exp. Stn., St. Paul, Minn.*

Table 1.--Averages[1] of survival and total seedling height for a plantation of 75 ponderosa pine provenances in the Black Hills, 1969-72

State and source number	Survival				Total height	State and source number	Survival				Total height	State and source number	Survival				Total height
	1969	1970	1971	1972	1972		1969	1970	1971	1972	1972		1969	1970	1971	1972	1972
	- - - *Percent* - - -				*Ft*		- - - *Percent* - - -				*Ft*		- - - *Percent* - - -				*Ft*
MT815	98	92	82	75	1.7	WY835	100	95	80	42	1.5	C0762	100	98	55	40	1.1*
WY830	100	100	95	70	1.6	MT827	90	88	68	42	1.4	C0859	98	95	50	30	1.1*
ND702	100	92	72	68	2.1	WY836	95	92	78	42	1.3	WY850	90	88	55	30	1.0*
WY831	100	98	85	68	1.6	WY848	95	90	70	42	1.2	MT819	95	78	48*	30	.6*
SD838	100	98	85	65	1.8	C0761	95	90	52	40	1.7	NB844	95	92	48*	28*	1.2
MT754	100	95	90	65	1.5	MT826	85*	85	58	38	1.7	MT817	80*	52*	45*	28*	.8*
SD839	98	92	78	62	1.8	SD840	95	92	58	38	1.6	NB853	95	92	68	25*	1.6
MT813	95	95	78	62	1.4	C0858	90	82	68	38	1.6	NB720	95	92	52	25*	1.6
MT821	98	98	85	60	1.5	MT828	95	95	58	38	1.5	WY846	98	98	68	25*	1.2
MT824	98	92	80	58	1.7	MT727	92	92	65	38	1.4	NB759	95	90	55	25*	1.2
NB851	98	95	70	58	1.2	ND701	80*	80	62	38	1.4	MT820	92	75	38*	25*	.9*
MT811	98	98	80	52	1.9	NB758	80*	75	42*	38	1.2	NB852	98	88	42*	22*	1.8
WY857	100	98	70	52	1.5	WY832	95	92	68	35	1.8	C0861	90	90	50	22*	1.2
WY847	98	92	65	52	1.4	MT812	98	90	70	35	1.6	C0763	100	90	50	20*	1.7
SD837	95	92	75	50	1.9	MT823	82	80	58	35	1.5	NM862	90	80	40*	20*	1.7
MT825	98	92	68	50	1.7	NB855	95	88	60	35	1.5	C0860	82*	75	38*	20*	1.4
SD854	88	85	75	50	1.6	SD757	95	95	48*	35	1.5	NM864	92	78	30*	18*	1.3
SD704	100	100	78	50	1.5	C0760	95	92	62	32	1.4	C0724	95	92	52	18*	.8*
NB723	98	92	75	48	1.6	NB722	92	85	60	32	1.3	NB856	88	82	42*	18*	.9*
MT814	95	92	72	48	1.5	MT822	88	80	55	32	1.2	C0764	92	80	38*	15*	1.4
WY833	92	88	68	45	1.5	NB721	95	90	62	30	2.2	C0765	98	92	45*	12*	1.2
NB845	95	88	65	45	1.5	MT818	70*	58*	40*	30	1.2	NM863	98	88	25*	8*	.3*
WY849	98	95	82	45	1.3	WY834	85*	80	72	58	.9*	NM766	68*	42*	15*	5*	.7*
WY829	100	98	95	45	1.2	MT816	95	88	75	55	1.1*	NM768	78*	32*	8*	5*	.4*
SD703	95	95	78	45	1.2	WA866	95	88	62	48	1.1*	NM767	85*	28*	0*	0*	0*

[1]Averages followed by * are significantly smaller than comparison source SD839 at 95 percent level of probability.

Mortality increased sharply during the fourth and fifth years. After the fifth growing season, average survival for the plantation was only 38 percent, while survival for the best provenances was little more than 60 percent. This is lower survival than one would normally expect for trees of local origin, and contrasts with the normal survival pattern in adjacent Great Plains where mortality usually is greatest during the first 2 years, then stabilizes as trees become established.

A number of factors were responsible in varying degrees for seedling mortality throughout the 5-year period. Perhaps the most important factor was competition from ground cover. A large band across the test area, where mortality was heaviest during 1971 and 1972, developed a noticeably heavier cover of grasses, forbs, and aspen sprouts when cultivation was discontinued.

Rodents took a heavy toll of trees at times in localized areas, especially where snow provided a cover for mice to work out into edges of the plantation. Grain treated with zinc phosphide was apparently effective in controlling mice most of the time. Strychnine-treated salt blocks were authorized for use during most of the 5-year period, and when placed in bait boxes scattered throughout the plantation, they effectively controlled porcupines and rabbits.

None of the losses to rodents suggested preferences for trees from certain provenances. Location in the plantation appeared to be more important than origin of the trees.

Shoestring root rot, *Armillaria mellea*, accounted for some mortality, especially in 1972, when inspection showed 66 seedlings killed by the fungus. The root rot has been a nuisance in other experimental forest plantations during the period, killing small numbers of seedlings of Black Hills source. There was no apparent pattern to *Armillaria* mortality in the provenance test block; seedling deaths appeared to be randomly distributed throughout the plantation.

Even, at best, average total height growth has not been especially good. After 5 years in the plantation (total age 8 years), trees from north-central Nebraska provenance 721 were the tallest with an average height of 2.2 ft (table 1). Trees from only one other provenance averaged as much as 2 ft in height after 5 years in the field. Local experience has shown that heights of 4 to 5 ft at total age 10 are not uncommon for Black Hills stock growing on good sites with limited competition.

If provenances outside the Black Hills area are evaluated as seed sources for reforestation in the Hills, better-than-local height growth by those trees might offset survival, which is poorer than for local sources. Initial stocking somewhat more than needed by local trees for later full site occupancy, to allow for the higher early mortality, could capitalize on inherently better growth and still give satisfactory stocking at later ages. Of course, plantation survival cannot be improved over time, except by replanting. Therefore, use of trees from provenances showing poor survival would be risky, even if height growth were comparable to local trees. For example, surviving trees from provenances 852 and 862 have reached heights equal to comparison source 839, but survival is so low that they hold little promise for planting in the Black Hills environment.

Length of the current year's leader, measured in 1970 and 1972, appeared only to supplement data on average total heights. Hence, they will not be reported. There was a predictable, positive relationship between average current annual height growth and average total heights for most provenances.

Conclusions

Results from long-term provenance research have sometimes shown that trees from distant seed sources can outperform local material in one or more respects. Early survival and height growth of ponderosa pine seedlings for a 5-year period from provenances rather far from the Hills in some cases exceeded Black Hills provenances. Other provenances were less noteworthy with little promise of being superior to local strains. Provenance WY 834 had exceptionally good survival but low height growth, and may develop into a more promising seed source later. Others, whose survival has been significantly lower than SD 839, but whose height growth has been comparable, need not be completely rejected, either. In other Black Hills plantations, they might perform better. Sources such as NB 852, CO 763, and NM 862 probably warrant additional trials.

Some sources were unable to cope with Black Hills conditions. New Mexico sources 863, 766, 767 have survived and grown so poorly that they will be of little value in plantations elsewhere in the Hills. Trees from other sources, which have less than 20 percent survival, are probably not worth additional testing in the Black Hills.

The trends of provenance survival and height growth will continue to be evaluated at 5-to 10-year intervals. A few provenances which show better early survival and height growth than Black Hills provenances should be evaluated more intensely, in blocks containing more trees, and for additional traits such as tree form, quality, and volume production.